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INTERPRETIVE ANALYSIS FOR FORAGE YIELD TRIAL DATA

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Abstract

Forage cultivar evaluation is often done in small plots with multiple harvests throughout the growing season. Data is often summarized by presenting a yearly total yield for each cultivar in addition to the mean for each harvest date. Data summarization often becomes burdensome and difficult to interpret. Regressing yield against a growth index associated with harvest dates can be utilized to describe forage performance in a concise and easily interpreted format. Subsets of data from tall fescue (*Festuca arundinacea* Schreb.) yield trials conducted in Alabama and Kentucky were used to demonstrate the technique. The analysis involves regressing yield of a cultivar against an index calculated as the mean of all entries at a harvest date minus the grand mean. The resulting regression coefficient (*b*) describes cultivar yield response over several harvests and is indicative of performance under variable growth conditions.

FORAGES used for grazing are best evaluated by means of grazing trials (Nelson, 1988). Grazing trials are costly in terms of labor, land, and money, however, so only a few cultivars are usually evaluated at any one time (Pedersen and Sleper, 1988). Most forage evaluation is therefore done in small plots with multiple harvests throughout the growing season. Data from multiple harvests are often summarized by presenting yearly totals for each cultivar in addition to the mean for each harvest date (Pedersen et al., 1982). Such data summarization can be effective when evaluating a small number of cultivars. When comparing many cultivars with many harvest dates, however, such data summarization becomes burdensome to use and difficult to interpret.

Our objective is to demonstrate how regressing yield against a growth index associated with harvest dates can be utilized to describe performance of forage cultivars over several harvests in a concise and easily interpreted format.

Materials and Methods

Subsets of data from tall fescue yield trials conducted in Alabama and Kentucky were used for this analysis. Four tall fescue cultivars, AU Triumph, Kentucky 31, Johnstone, and Martin, and AU Vigor (an Auburn University experimental line) were common to both yield trials and were selected for this analysis to represent a broad array of characteristics.

The Alabama yield trial was seeded at Marion Junction, AL, on 26 Sept. 1985. The Kentucky yield trial was seeded at Lexington, KY, and 1 Sept. 1988. Soil types at the two locations were Sumter clay (fine-silty, carbonatic, thermic Rendollic Eutrochrept) and Maury silt loam (fine, mixed, mesic Typic Paleudalf), respectively. The design was a randomized complete block with four replications at both locations. Seeds were planted with a small-plot drill in 178-mm rows at a depth of 6 to 12 mm. Plot dimensions were 1.5 by 6 m. At the Alabama site, N was applied at 67 kg ha^{-1} each February and August, with other minerals being added according to soil test recommendations. At the Kentucky site, N was applied at 67 kg ha^{-1} each March, June, and September, with no other mineral fertilization. Broadleaf weeds were controlled with broadcast application of 2,4-D amine ([2,4-dichlorophenoxy] acetic acid) as needed.

Plots were harvested on approximately 1-mo intervals whenever at least 15 cm of growth had accumulated on any plots. A 0.8- by 6-m section was removed from the center of each plot to a stubble height of approximately 8 cm, then weighed. Subsamples from each plot were dried at 65 °C to determine dry matter content.

Data from the Alabama trial in 1987 and the Kentucky trial in 1989 were used to demonstrate the analysis. Yield was regressed against a growth index calculated as the mean of all entries at a harvest date minus the grand mean. The resulting regression coefficient (*b*) is descriptive of cultivar yield response over several harvests. A coefficient equal to one indicates that a cultivar responds similarly with respect to the growth index over all harvests. Cultivars with *b* greater than one respond relatively well to favorable growth conditions but respond rather poorly when growth conditions are less than favorable. Conversely, cultivars with *b* less than one perform relatively well under unfavorable growth conditions but perform relatively poorly under favorable growth

Table 1. Traditional summarization of tall fescue yields by month in 1987, Alabama location.

Cultivar	April	May	June	December	Total
	kg ha^{-1}				
AU Vigor	2489	1230	409	80	4207
Johnstone	795	987	516	0	2298
Kentucky 31	1015	1015	516	584	3129
Martin	1602	1281	608	308	3799
AU Triumph	1846	1008	808	669	4330
LSD ($P \leq 0.05$)	368	218	193	329	738

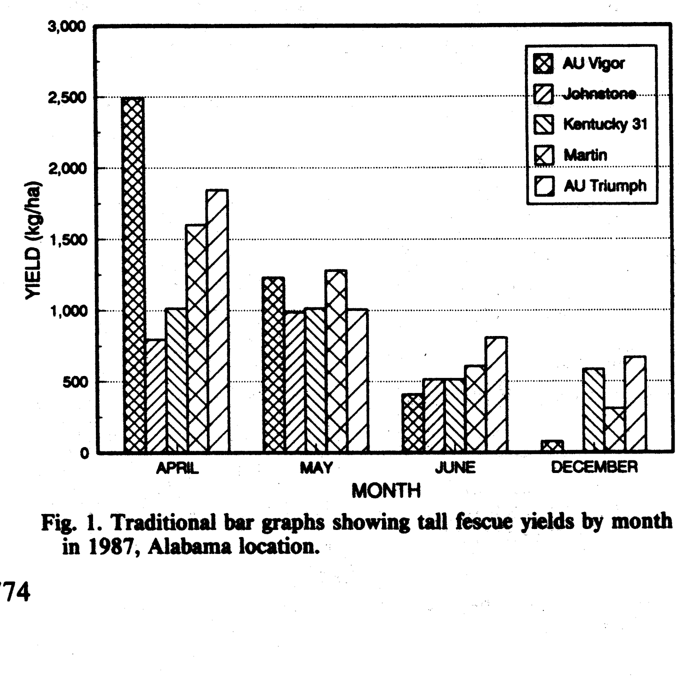

Fig. 1. Traditional bar graphs showing tall fescue yields by month in 1987, Alabama location.

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conditions. The hypothesis $b = 1$ was tested for each cultivar using a standard t-test (Steel and Torrie, 1980). Comparison of the regressions of all cultivars was made by testing the null hypothesis $b_1 = b_2 = b_n$ using analysis of covariance procedures (Zar, 1974). The standard error of the estimate ($s_{y \cdot x}$) is indicative of the accuracy of the regression.

Results and Discussion

Mean cultivar yields by harvest date followed by a yearly total yield for each cultivar are shown in Tables 1 and 2. Note that the number of columns of data for each cultivar increases with each additional harvest date. Such data can be presented graphically as bar graphs (Fig. 1 and 2), but these become very difficult to interpret if numerous cultivars are represented on the graph.

The results of the regression analysis are shown in Tables 3 and 4. Note that the performance of each cultivar is represented by three descriptors regardless of the number of harvest dates. Such information can also be presented graphically as a single straight line plot for each cultivar (Fig. 3 and 4). In these plots, however, harvest dates are not shown chronologically, but rather sequentially according to their growth index.

Several conclusions can be drawn concerning the relative usefulness of these five entries in Alabama and Kentucky. In Alabama, AU Vigor had the highest yields in favorable growth periods (positive index), but the lowest yields during unfavorable growth periods (negative index). As such, it would be expected to provide inconsistent yields (although relatively high yields at times) under grazing and be of limited value for season-long use. Kentucky 31 is the least responsive to improving growth periods. It would provide season-long grazing, but at low levels since its yields were relatively low except during the unfavorable growth periods. Johnstone yields were low across all

Table 2. Traditional summarization of tall fescue yields by month in 1989, Kentucky location.

Cultivar	April	May	June	July	August	Sept.	October	Total
	kg ha^{-1}							
AU Vigor	1178	1523	1546	558	235	417	513	5970
Johnstone	1512	1653	363	734	576	734	576	7651
Kentucky 31	1429	2181	1624	726	324	744	672	6955
Martin	1625	1641	1649	921	491	830	834	7990
AU Triumph	1870	1686	1870	913	498	822	763	8400
LSD ($P \leq 0.05$)	225	495	242	110	95	205	168	1019

Table 3. Regression of tall fescue yield against a growth index associated with harvest dates, Alabama location, 1987.

Cultivar	Mean Yield	b†	$s_{y \cdot x}$‡
	kg ha^{-1}		kg ha^{-1}
AU Vigor	1052	1.93	218
Johnstone	575	0.64	302
Kentucky 31	783	0.45	142
Martin	950	1.08	86
AU Triumph	1083	0.90	233
SE	105	0.22	–

† b is a regression coefficient that describes cultivar yield response to a varying growth index (the mean of all cultivars at a harvest date minus the grand mean).
‡ $S_{y \cdot x}$ is the standard deviation from regression for each cultivar.

Table 4. Regression of tall fescue yield against a growth index associated with harvest dates, Kentucky location, 1989.

Cultivar	Mean Yield	b†	$S_{y \cdot x}$‡
	kg ha^{-1}		kg ha^{-1}
AU Vigor	853	0.94	141
Johnstone	1093	1.12	160
Kentucky 31	1100	1.12	237
Martin	1142	0.83	133
AU Triumph	1204	0.98	251
SE	46	0.09	–

† b is a regression coefficient that describes cultivar yield response to a varying growth index (the mean of all cultivars at a harvest date minus the grand mean).
‡ $S_{y \cdot x}$ is the standard deviation from regression for each cultivar.

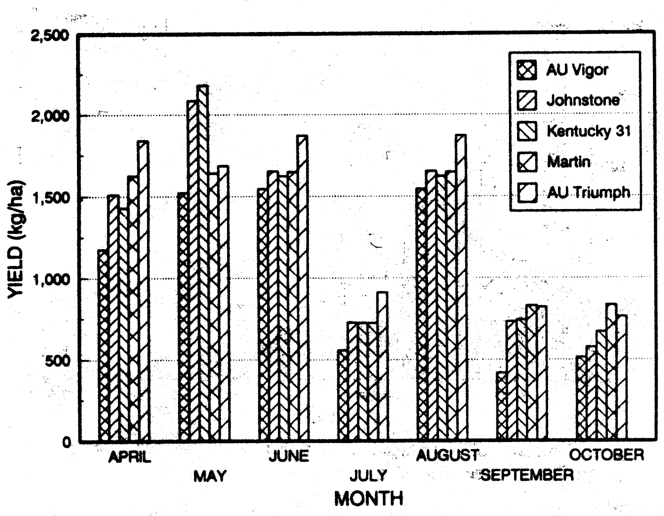

Fig. 2. Traditional bar graphs showing tall fescue yields by month in 1989, Kentucky location.

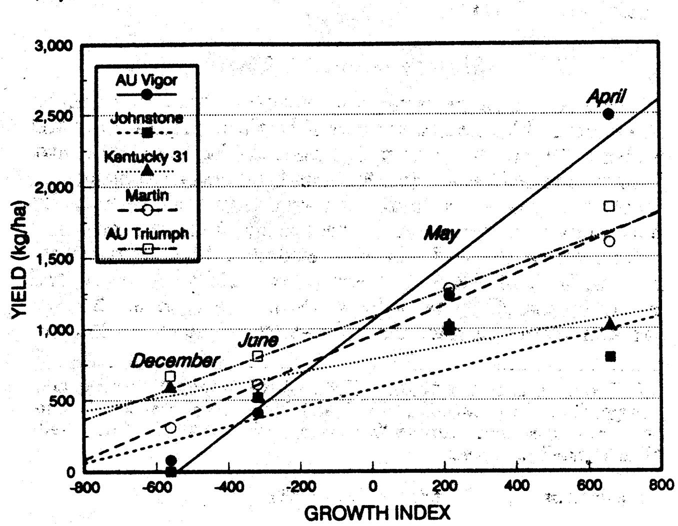

Fig. 3. Regression of tall fescue yield against a growth index associated with harvest dates, Alabama location, 1987.

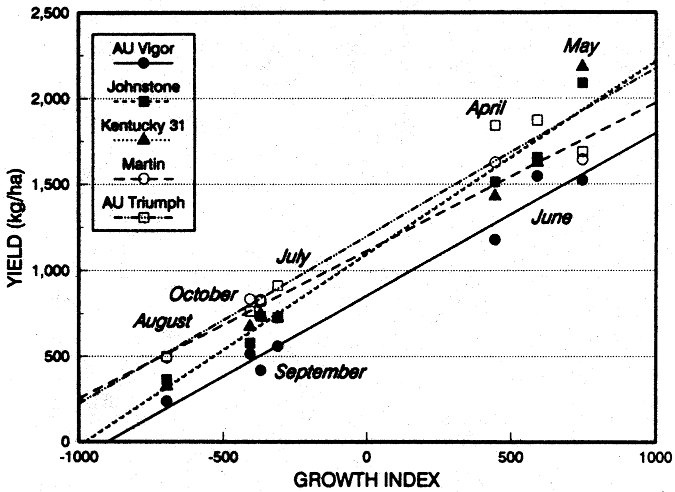

Fig. 4. Regression of tall fescue yield against a growth index associated with harvest dates, Kentucky location, 1989.

harvest dates. AU Triumph and Martin had high yields across all harvest dates and responded well to improving growth periods. In Alabama, they would appear to be the best cultivars.

In Kentucky, AU Vigor is the lowest yielding cultivar at all harvest dates. In general, the other four cultivars all had high yields and responded well to improving growth periods (increasing index).

Conclusions

Forage performance can be presented in a concise and easily interpreted format by regressing yield against a growth index associated with harvest dates. The practical value of such a technique will increase as the number of cultivars evaluated in a test increases. Although we have demonstrated this technique on yield data, it should be as useful for interpreting other forage parameters, such as quality measures, for multiple harvest tests comparing large numbers of cultivars.

References

Nelson, C.J. 1988. Physiological considerations in forage management. p. 262–273. *In* Proc. 1988 Forage and Grassland Conf., Baton Rouge, LA. 11–14 April. Am. For. Grassl. Council, Belleville, PA.

Pedersen, J.F., C.S. Hoveland, and R.L. Haaland. 1982. Performance of tall fescue varieties in Alabama. Ala. Exp. Stn. Cir. 262.

Pedersen, J.F., and D.A. Sleper. 1988. Considerations in breeding endophyte-free tall fescue forage cultivars. J. Prod. Agric. 1:127–132.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics. 2nd ed. McGraw-Hill Book Co., New York.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc. Englewood, Cliffs, NJ.